GE Energy
Digital Energy

Smart Grid: Definition, Concepts, Policy, Standards, Deployments and Lessons Learned

John McDonald, P.E.
Director, Technical Strategy & Policy Development

IEEE-SA Board of Governors
IEEE PES Past President
IEEE Division VII Past Director
IEEE PES Substations Committee Past Chair
IEEE Fellow
NIST SGIP Governing Board Chair
CIGRE USNC VP, Technical Activities

April 24, 2012

imagination at work

Smart Grid Definition and Concepts

Smart Grid View

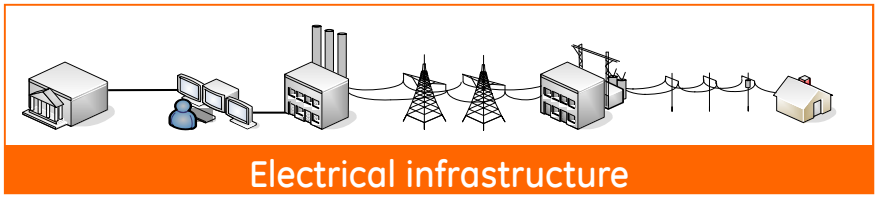
The integration of electrical and information infrastructures, and the incorporation of automation and information technologies with our existing electrical network.

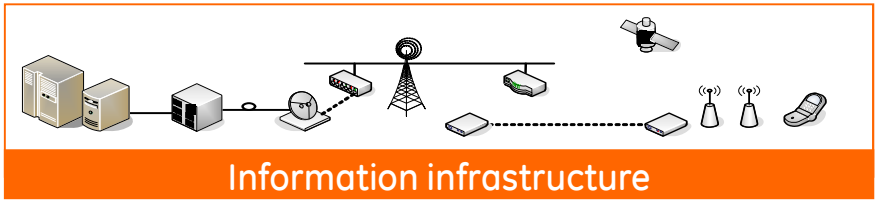
Comprehensive solutions that:

- ✓ Improve the utility's power reliability, operational performance and overall productivity
- ✓ Deliver increases in energy efficiencies and decreases in carbon emissions
- ✓ Empower consumers to manage their energy usage and save money without compromising their lifestyle
- ✓ Optimize renewable energy integration and enabling broader penetration

That deliver meaningful, measurable and sustainable benefits to the utility, the consumer, the economy and the Environment.

More Focus on the Distribution System





imagination at work

A "Smarter" Grid

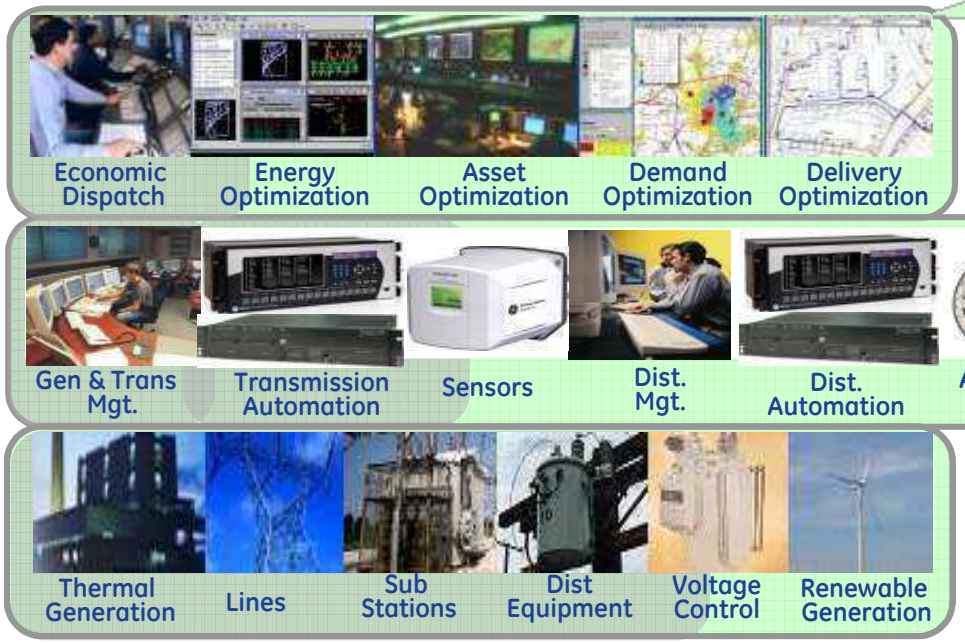
Enabled
Utility Managers

'New Applications enabled by Additional Infrastructure'

Management
" Applications"

Control
"How Power Flows"

Heavy Metal
" Generate & Deliver Power"



Enabled
Consumers

Old Grid
Smart Grid Adds

Old Grid

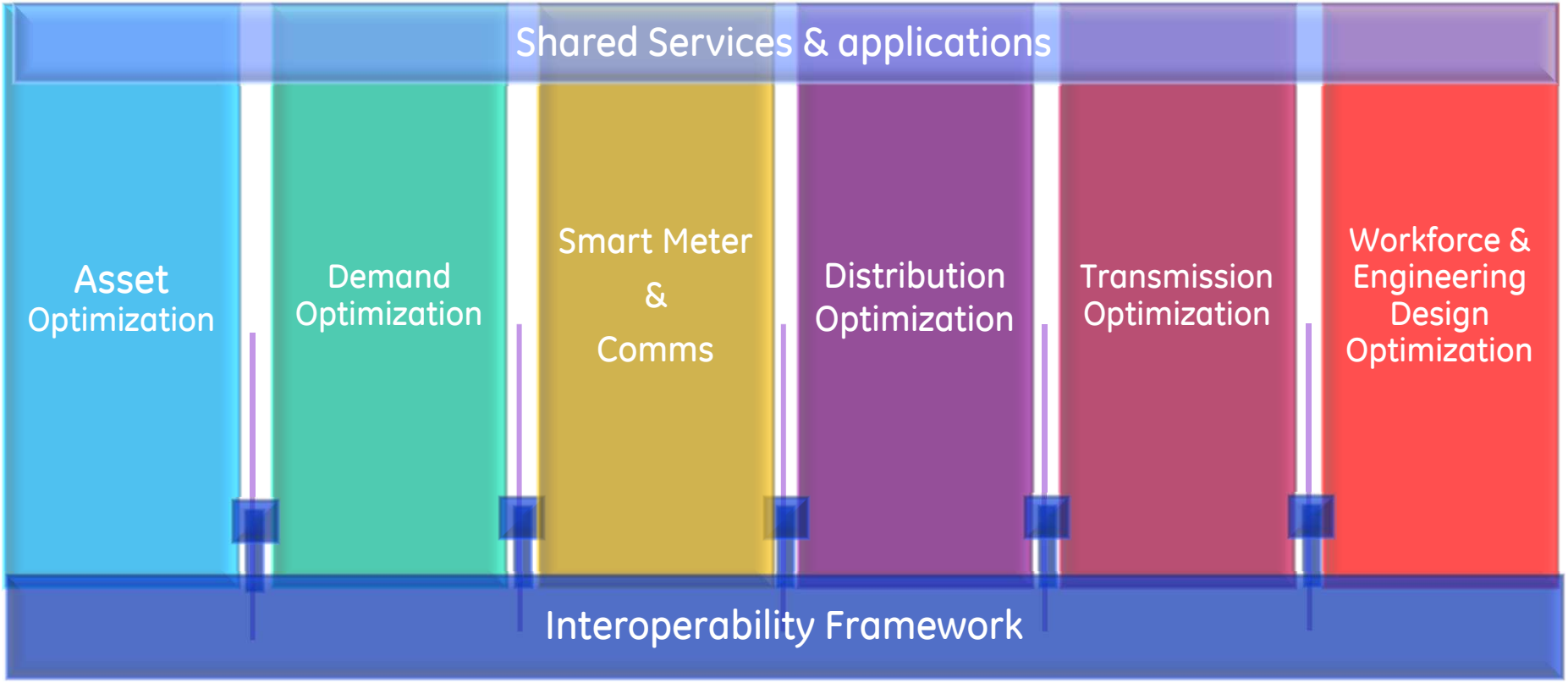
- You call when the power goes out.
- Utility pays whatever it takes to meet peak demand.
- Difficult to manage high Wind and Solar penetration
- Cannot manage distributed generation safely.
- ~10% power loss in T&D

Smart Grid

- Utility knows power is out and usually restores it automatically.
- Utility suppresses demand at peak. Lowers cost. Reduces CAPEX.
- No problem with higher wind and solar penetration.
- Can manage distributed generation safely.
- Power Loss reduced by 2+%... lowers emissions & customer bills.

imagination at work

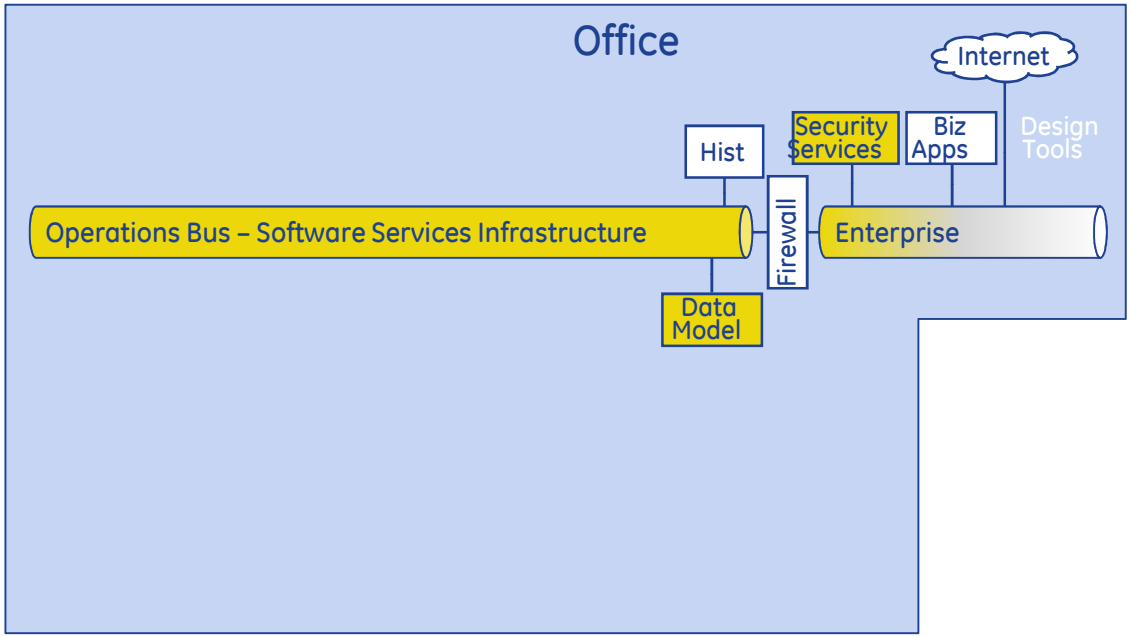
Smart Grid Holistic Solutions



Transitioning from products/systems to holistic solutions

imagination at work

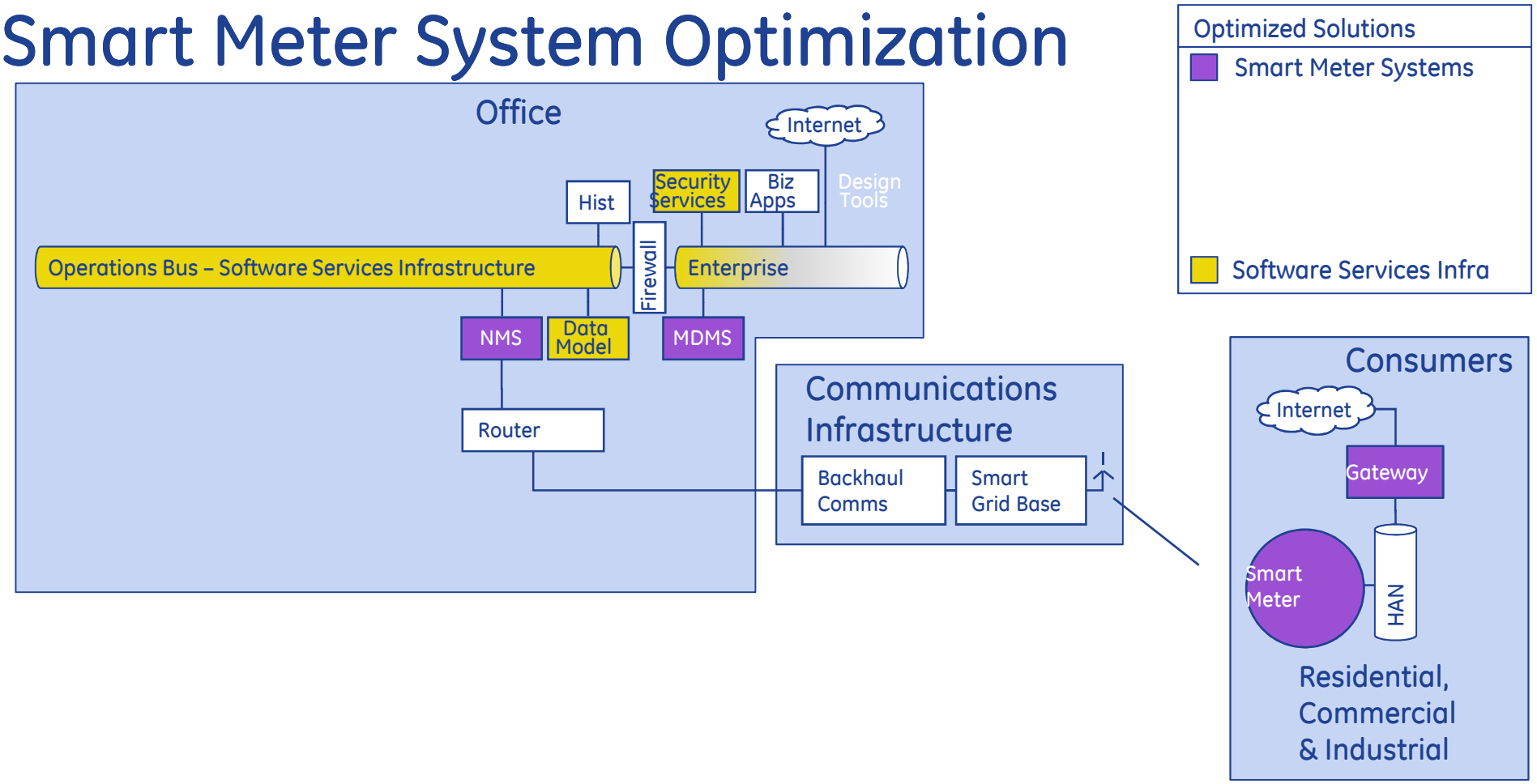
Software Services Infrastructure



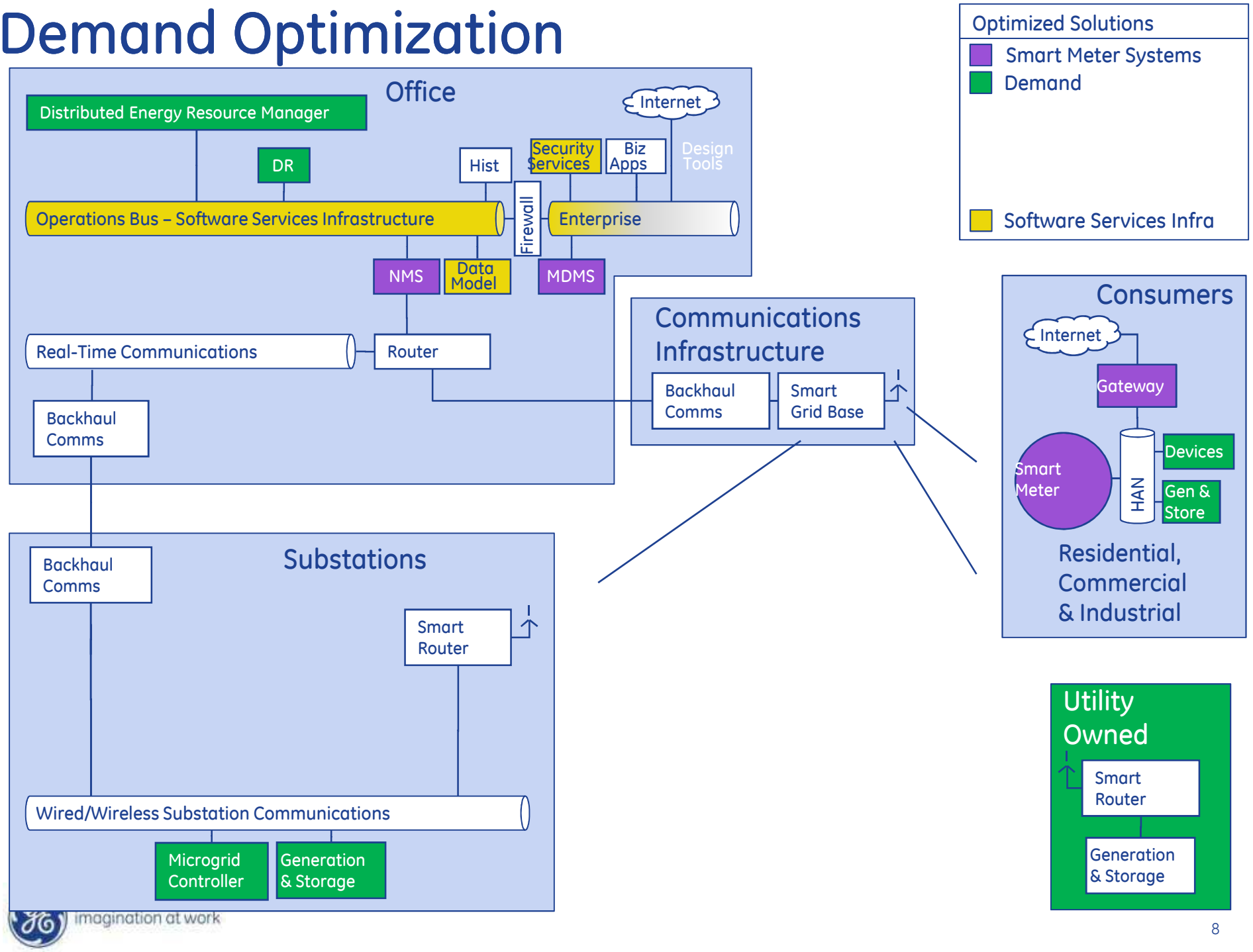
Optimized Solutions

Software Services Infra

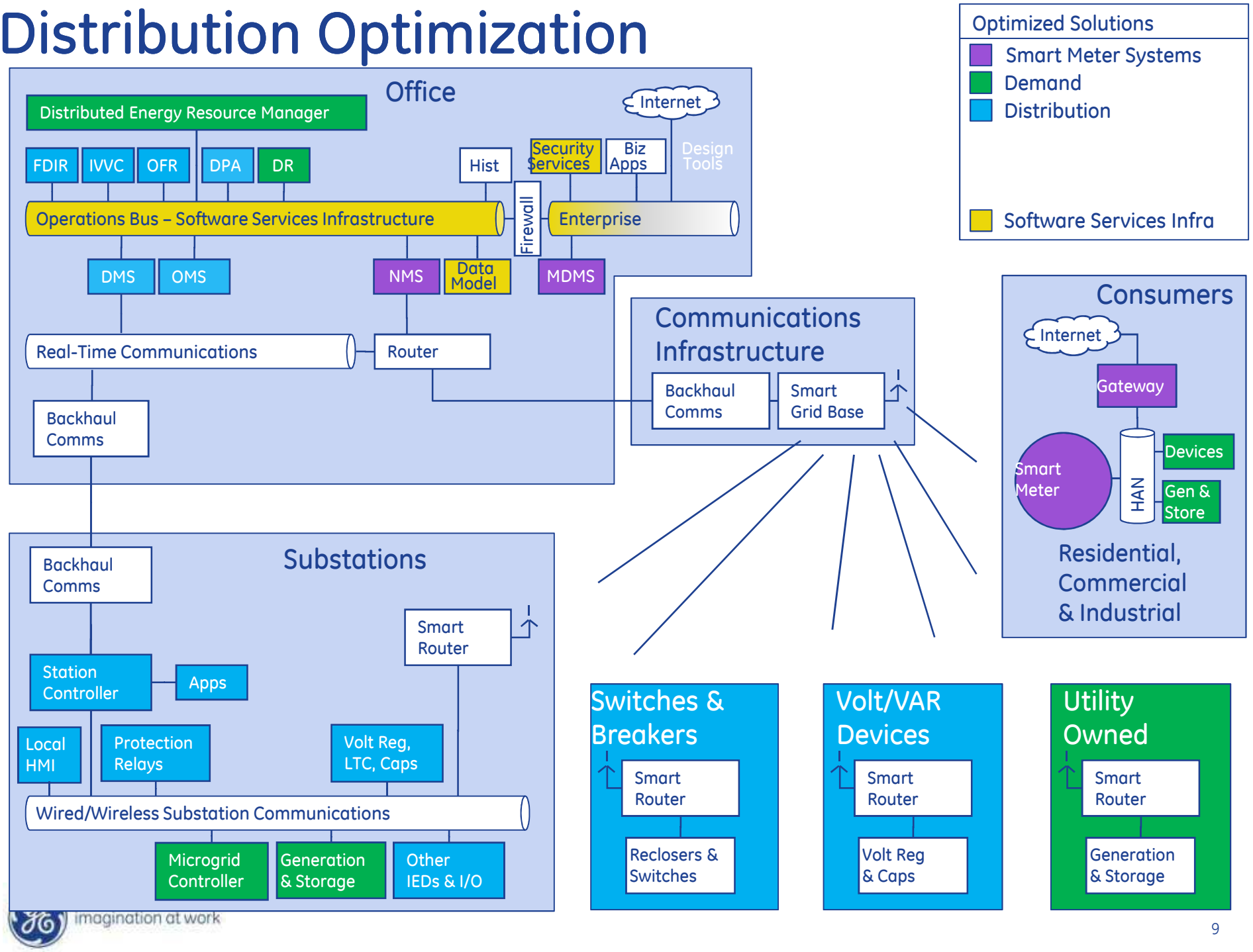
Smart Meter System Optimization



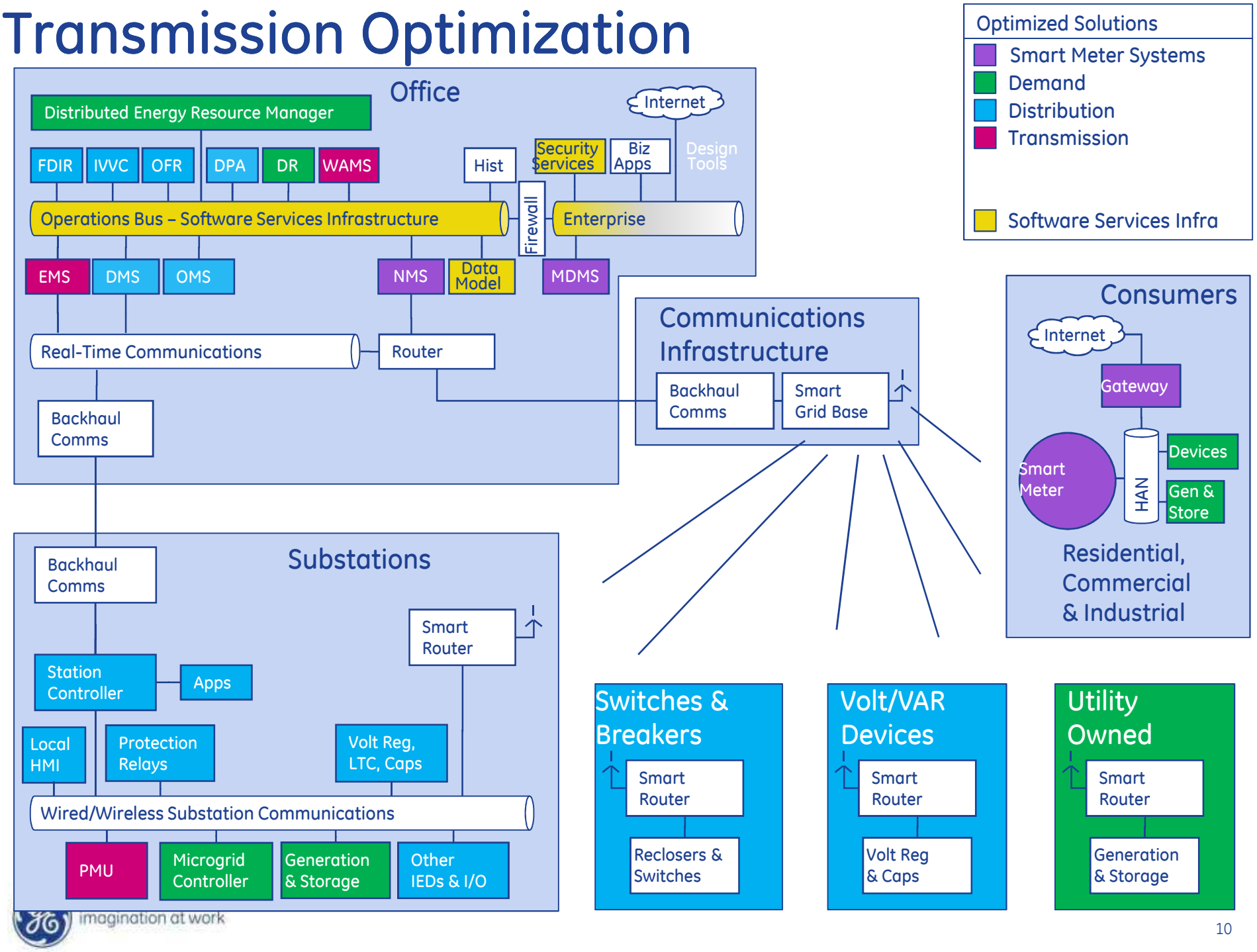
Demand Optimization



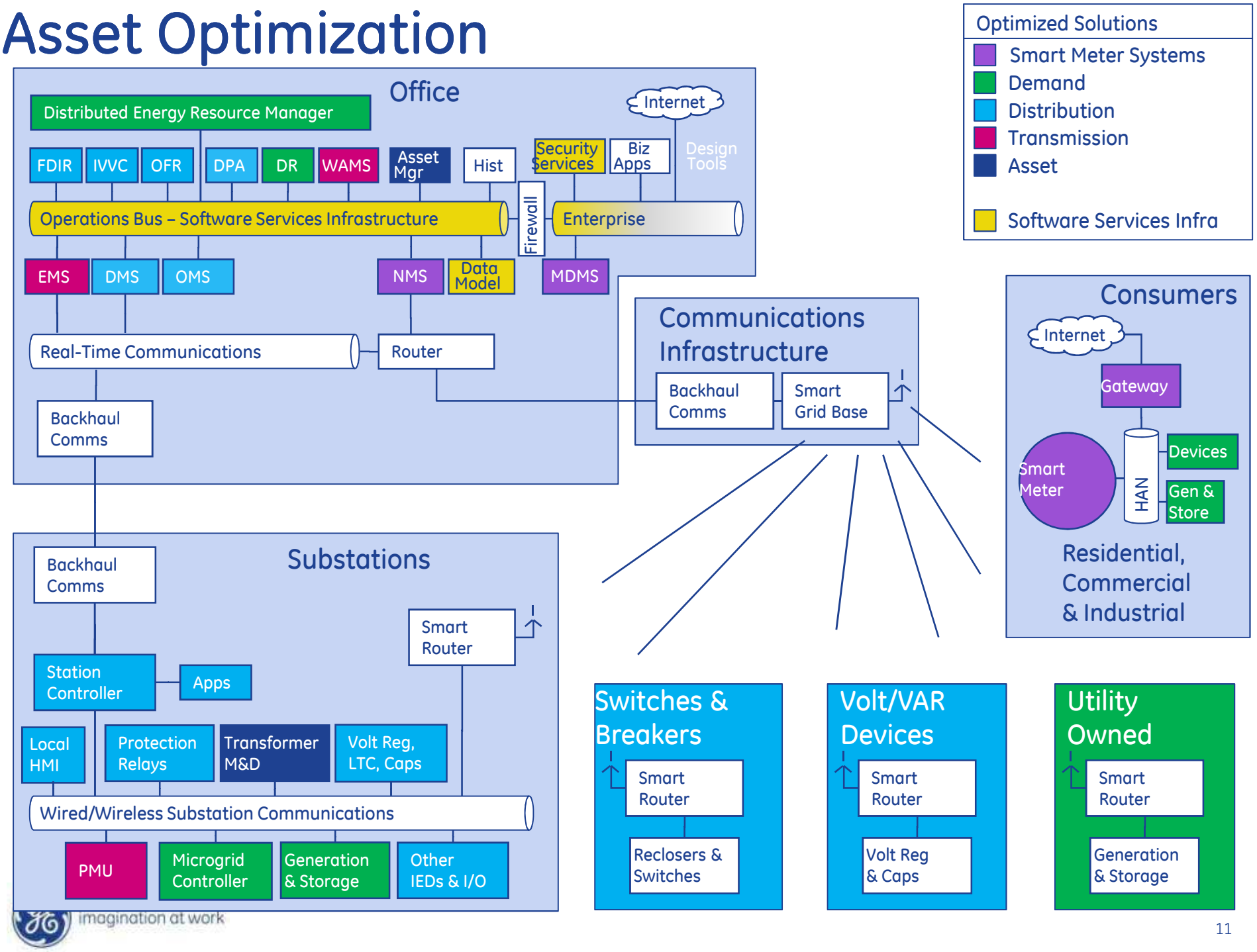
Distribution Optimization



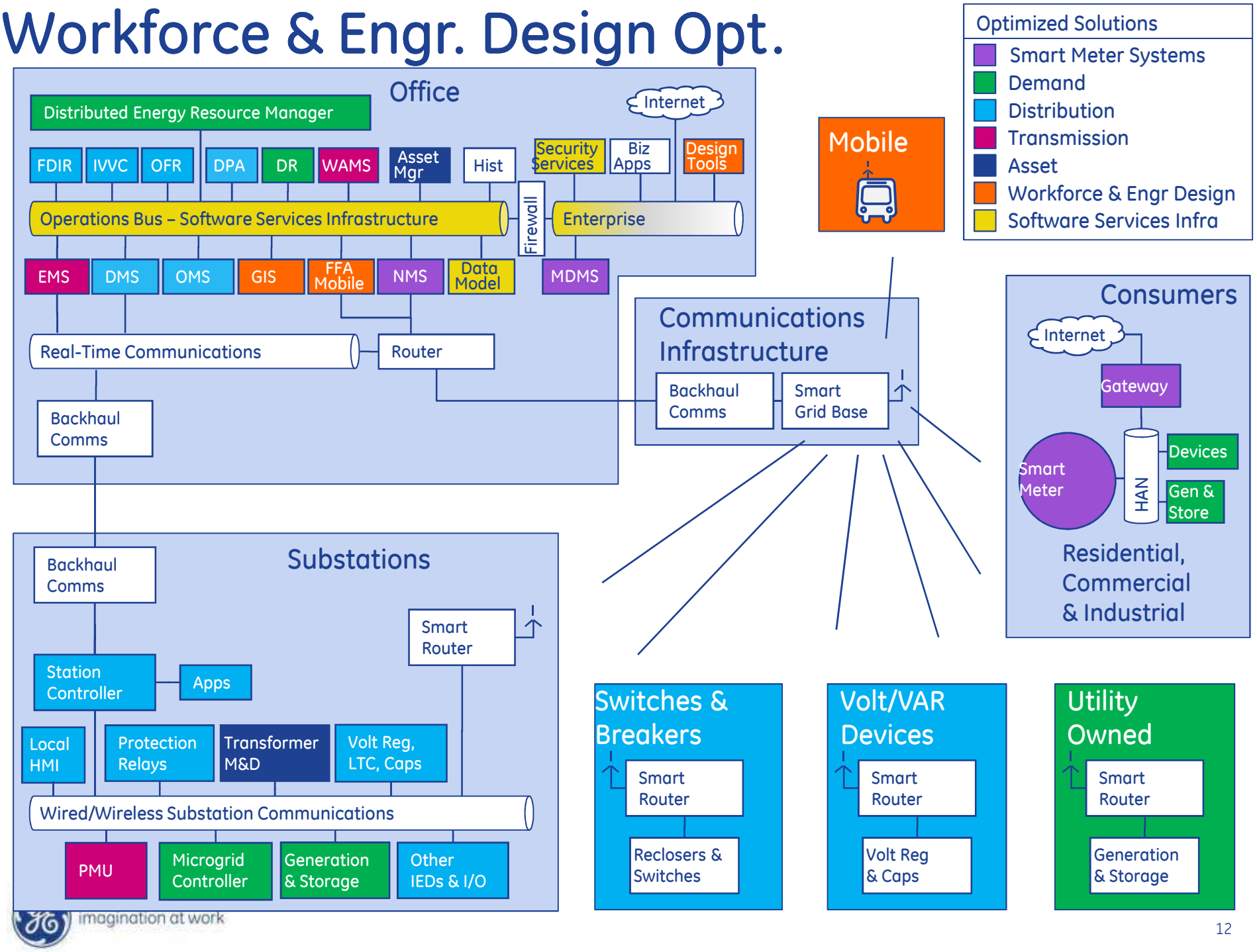
Transmission Optimization



Asset Optimization

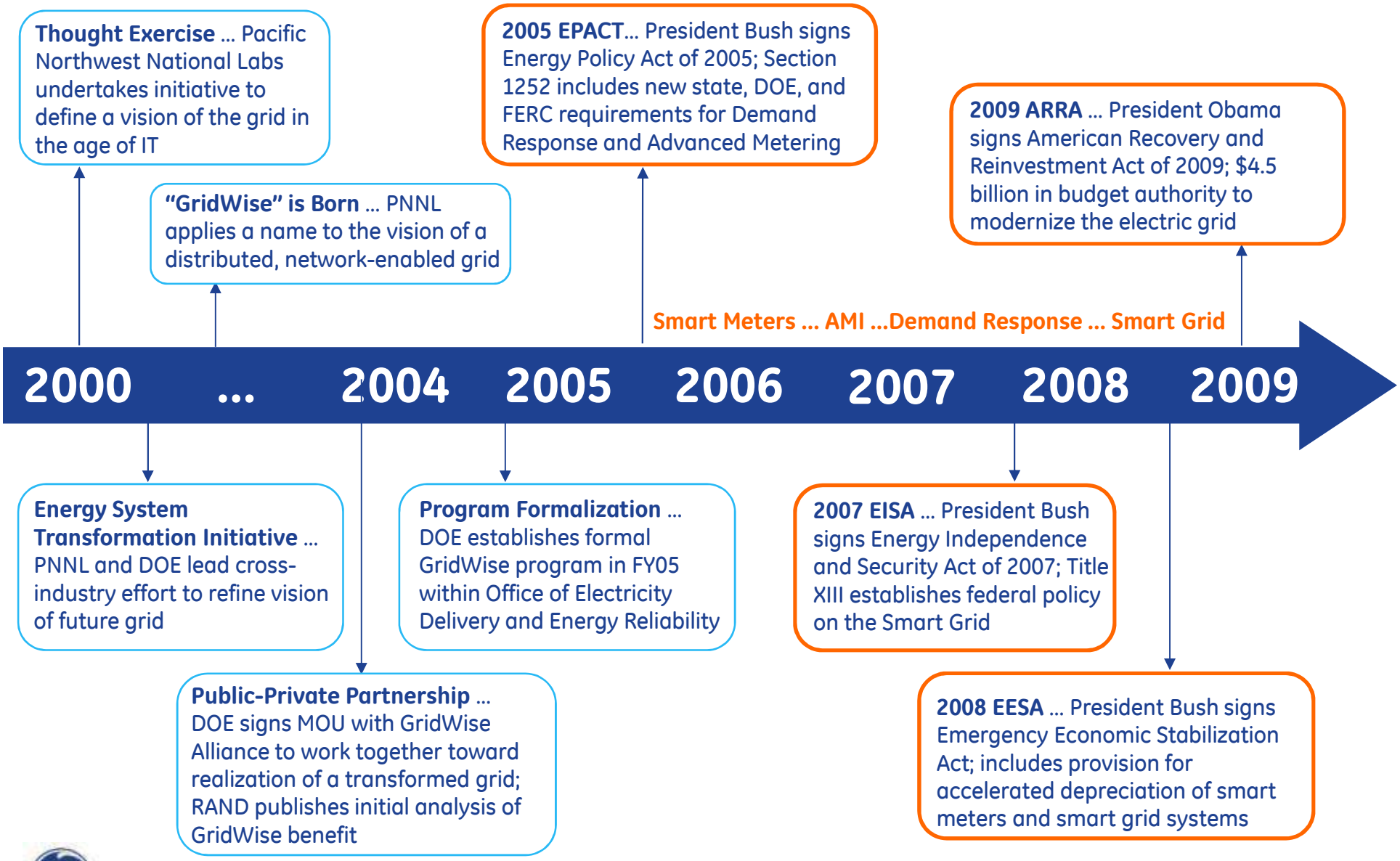


Workforce & Engr. Design Opt.



Smart Grid Policy

A historical review for the United States



imagination at work

Example: state legislation

Characteristics of effective policy

Relevant

- Target a particular smart grid technology or benefit;
- Disincentivize alternative means of compliance

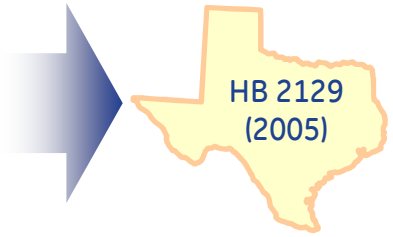
Specific

- Identify required functionalities
- Include timelines for implementation

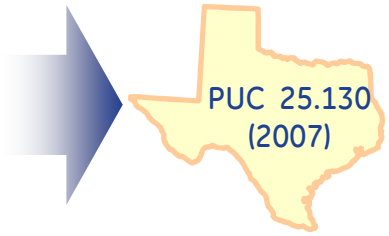
Proactive

- Establish cost recovery parameters
- Anticipate and address implementation challenges

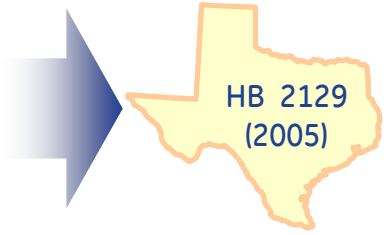
Ex) Texas smart meter experiences



- "Encouraged" utility adoption of smart meters and AMI
- Subsequent linkage to energy efficiency (HB 3693, 2007)



- Identified minimum technical capabilities for smart meters



- Directed PUC to establish a surcharge for cost recovery

Policy and standards are closely linked

Competing standards can inhibit markets

By default…

- Disparate standards bodies give rise to competing standards
- Firms face higher transaction costs, diseconomies of scale

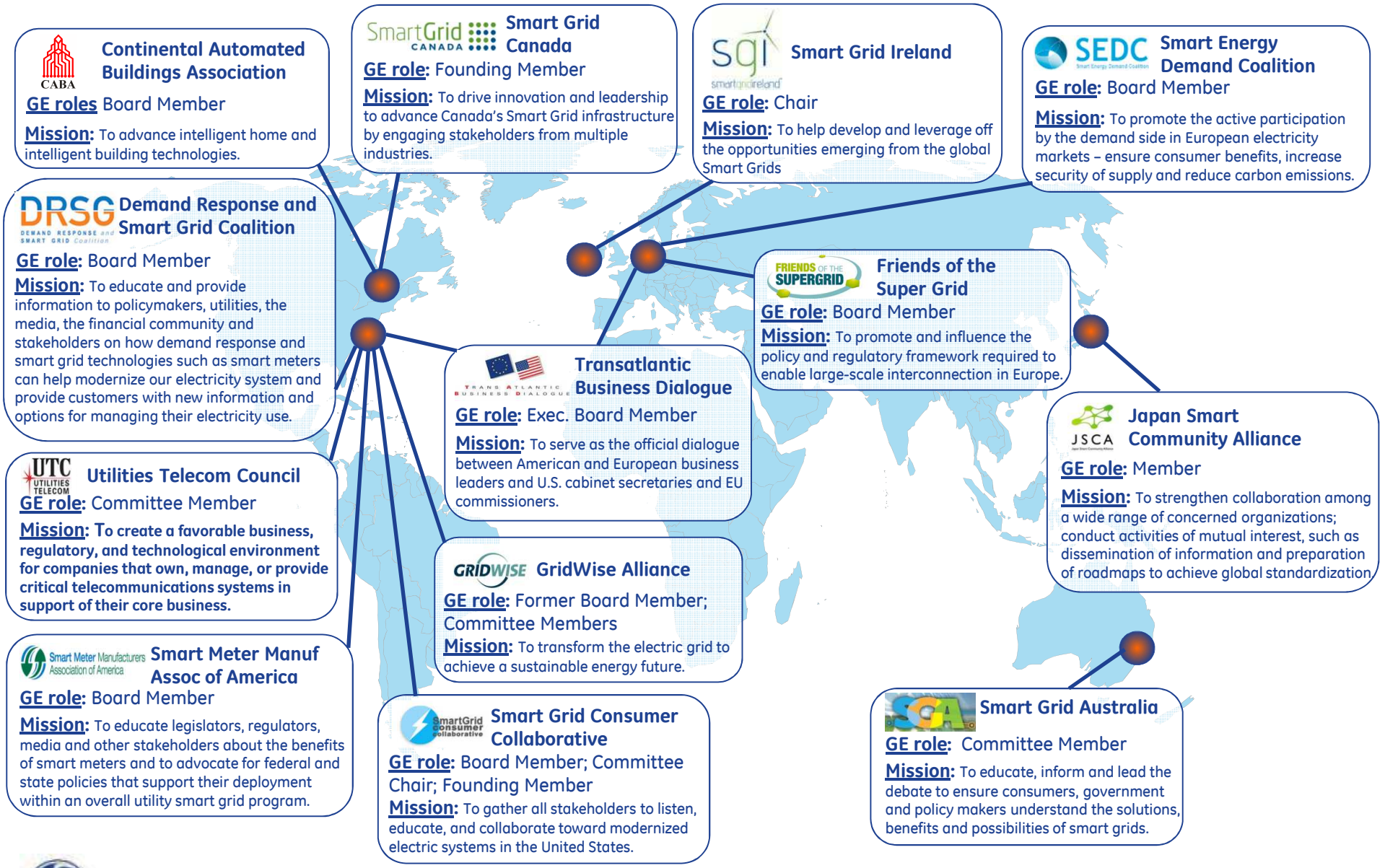
By design…

- Technical standards as industrial policy…non-tariff trade barriers
- "Prescriptive" standards development undermines "market-based" approach

Leading to calls for harmonization

- Country-to-country MOUs
  - ✓Joint R&D
  - ✓Standards working groups
- Foreign participation in national/regional standards bodies
- Government support for development of international standards
- Internationally-recognized conformance testing procedures
- Funding for standards development in emerging markets
- Other…

Leadership Makes the Difference



Continental Automated Buildings Association
GE roles Board Member
Mission: To advance intelligent home and intelligent building technologies.

Smart Grid Canada
GE role: Founding Member
Mission: To drive innovation and leadership to advance Canada's Smart Grid infrastructure by engaging stakeholders from multiple industries.

Smart Grid Ireland
GE role: Chair
Mission: To help develop and leverage off the opportunities emerging from the global Smart Grids

Smart Energy Demand Coalition
GE role: Board Member
Mission: To promote the active participation by the demand side in European electricity markets – ensure consumer benefits, increase security of supply and reduce carbon emissions.

Demand Response and Smart Grid Coalition
GE role: Board Member
Mission: To educate and provide information to policymakers, utilities, the media, the financial community and stakeholders on how demand response and smart grid technologies such as smart meters can help modernize our electricity system and provide customers with new information and options for managing their electricity use.

Friends of the Super Grid
GE role: Board Member
Mission: To promote and influence the policy and regulatory framework required to enable large-scale interconnection in Europe.

Transatlantic Business Dialogue
GE role: Exec. Board Member
Mission: To serve as the official dialogue between American and European business leaders and U.S. cabinet secretaries and EU commissioners.

Japan Smart Community Alliance
GE role: Member
Mission: To strengthen collaboration among a wide range of concerned organizations; conduct activities of mutual interest, such as dissemination of information and preparation of roadmaps to achieve global standardization

Utilities Telecom Council
GE role: Committee Member
Mission: **To create a favorable business, regulatory, and technological environment for companies that own, manage, or provide critical telecommunications systems in support of their core business.**

GridWise Alliance
GE role: Former Board Member; Committee Members
Mission: To transform the electric grid to achieve a sustainable energy future.

Smart Meter Manuf Assoc of America
GE role: Board Member
Mission: To educate legislators, regulators, media and other stakeholders about the benefits of smart meters and to advocate for federal and state policies that support their deployment within an overall utility smart grid program.

Smart Grid Consumer Collaborative
GE role: Board Member; Committee Chair; Founding Member
Mission: To gather all stakeholders to listen, educate, and collaborate toward modernized electric systems in the United States.

Smart Grid Australia
GE role: Committee Member
Mission: To educate, inform and lead the debate to ensure consumers, government and policy makers understand the solutions, benefits and possibilities of smart grids.

imagination at work

Global lessons learned

No "one size fits all" … focus on outcomes

- Feed-in tariff
- Quota/RPS
- Tax incentive
- Auction/Tender

Attributes of an effective policy

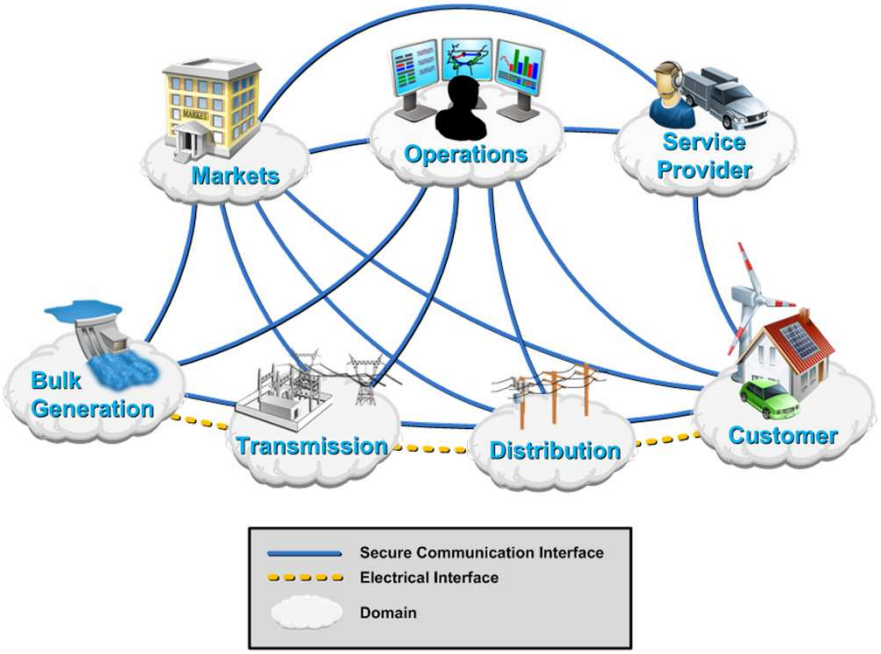
- Stable, long-term commitment
- Rewards performance
- Supports project financial viability
- Non-compliance "teeth"
- Tied to enabling policies (transmission, siting)
- Reasonable cost containment measures

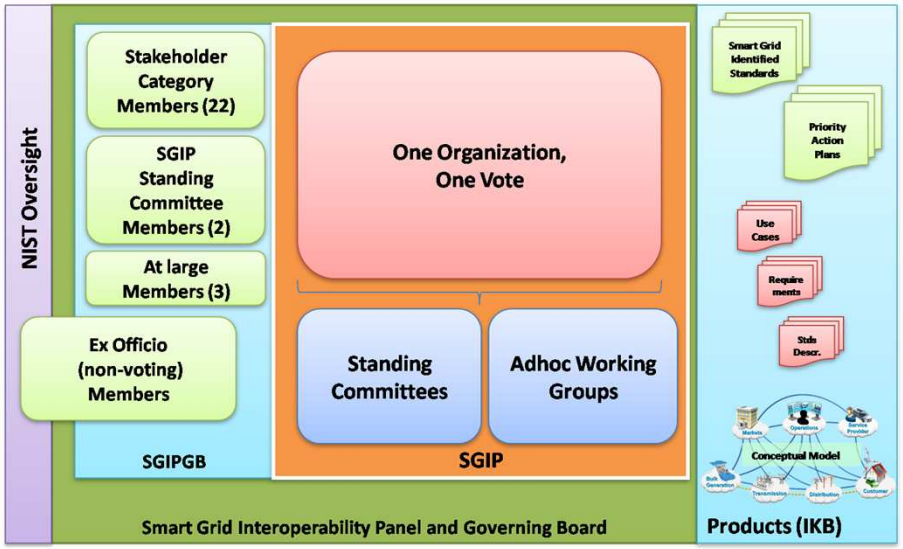
Smart Grid Standards Development and Interoperability

Example: Standards Framework

National Institute of Standards and Technology (NIST)

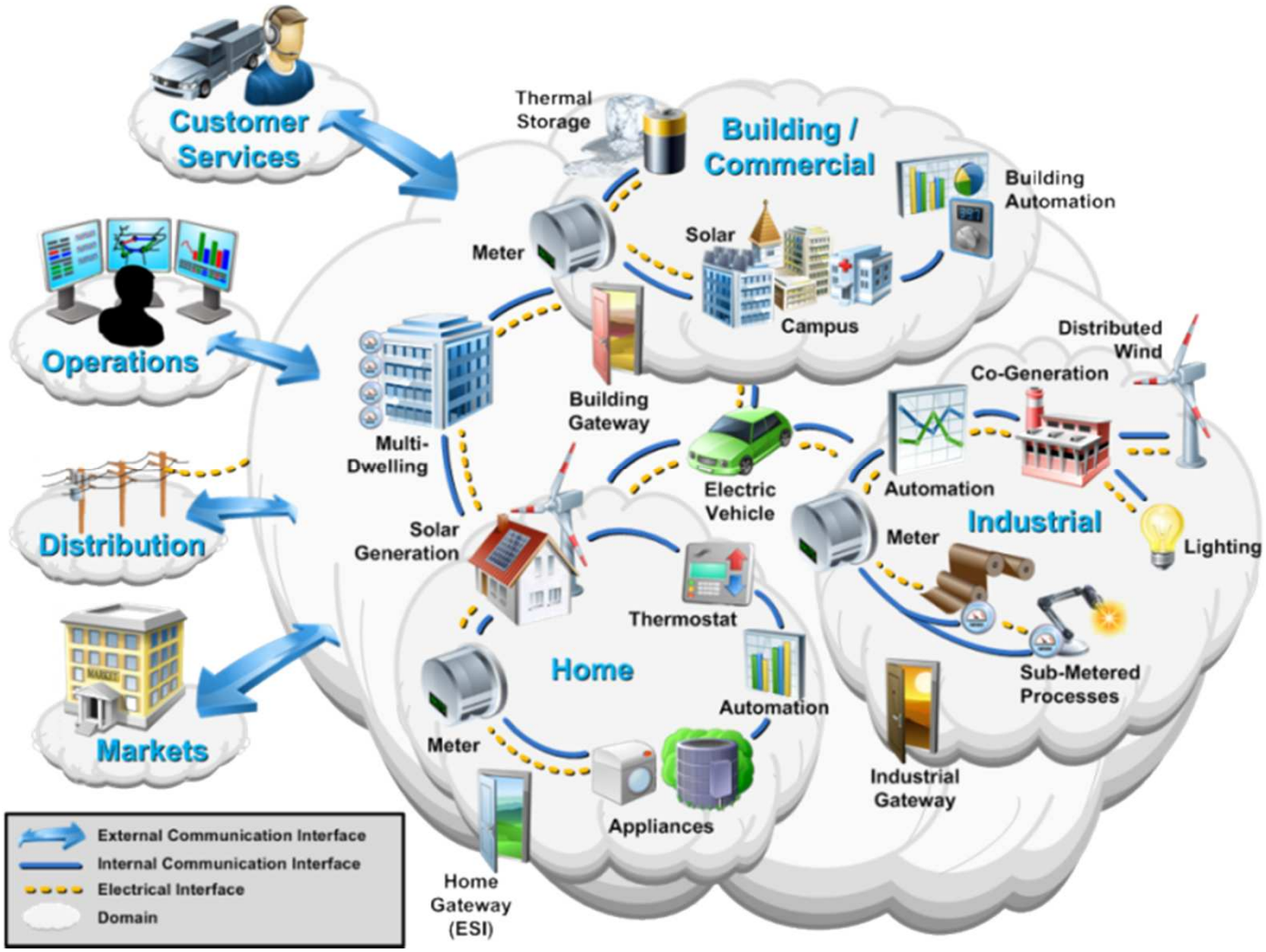
... Smart Grid Conceptual Reference Model
... Smart Grid Interoperability Panel Organizational Structure





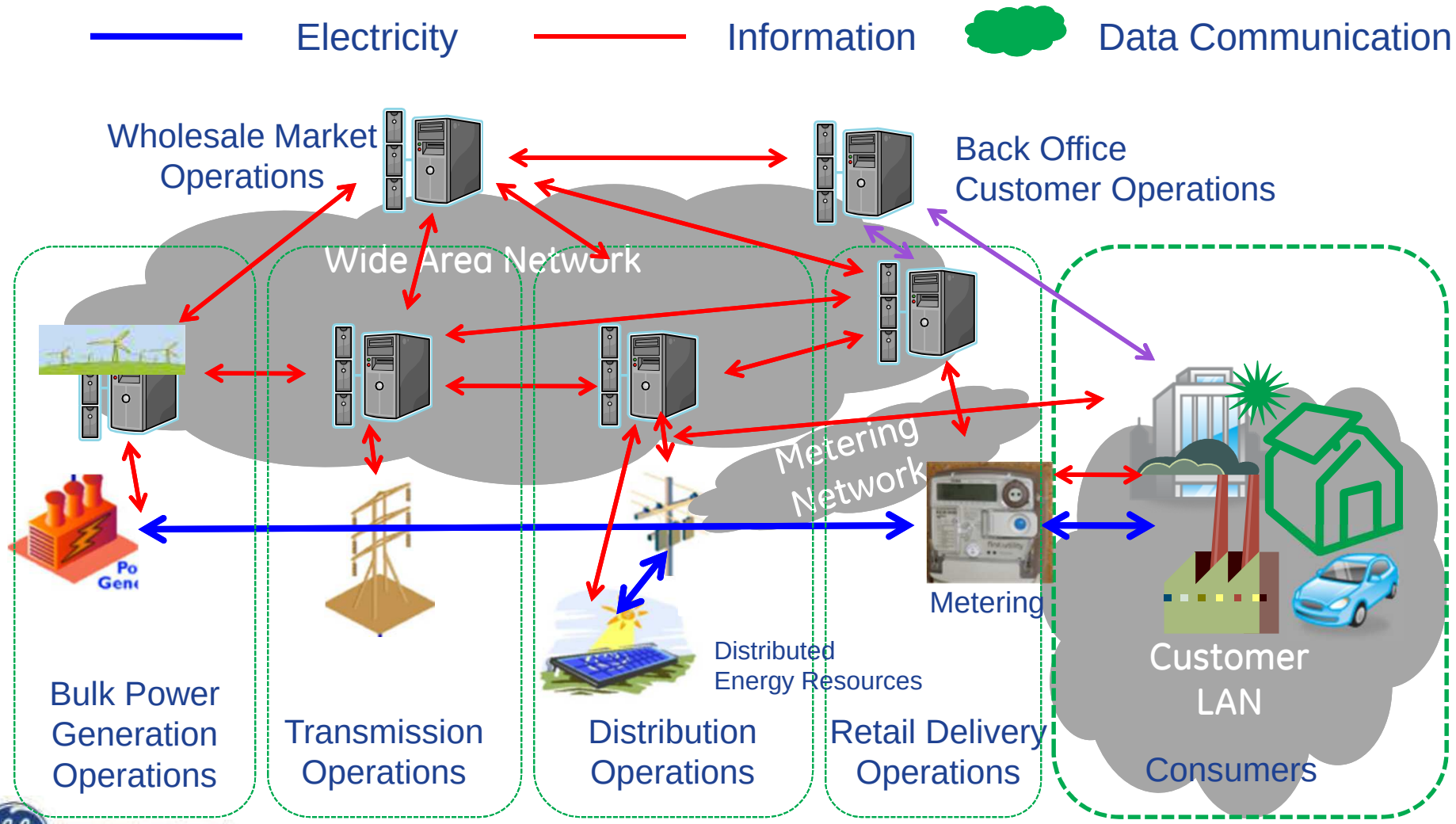
imagination at work

Model Build-out for the Customer



What Interoperability Standards are Needed?

Standards are needed for each of the interfaces shown to support many different smart grid applications. Standards are also needed for data networking and cyber security.



imagination at work

A Clear Plan to Mobilize and Accelerate

Priority Action Plan	Schedule	Deliverables	Resources
PAP 00 - Meter Upgradability Standard (TASKING COMPLETE)			
PAP 01 - Role of IP in the Smart Grid (TASKING COMPLETE)			
PAP 02 - Wireless Communications for the Smart Grid			
PAP 03 - Common Price Communication Model			
PAP 04 - Common Scheduling Mechanism			
PAP 05 - Standard Meter Data Profiles			
PAP 06 - Common Semantic Model for Meter Data Tables			
PAP 07 - Electric Storage Interconnection Guidelines			
PAP 08 - CIM for Distribution Grid Management			
PAP 09 - Standard DR and DER Signals			
PAP 10 - Standard Energy Usage Information (TASKING COMPLETE)			
PAP 11 - Common Object Models for Electric Transportation			
PAP 12 - IEC 61850 Objects/DNP3 Mapping			
PAP 13 - Time Synchronization, IEC 61850 Objects/IEEE C37.118 Harmonization			
PAP 14 - Transmission and Distribution Power Systems Model Mapping			
PAP 15 - Harmonize Power Line Carrier Standards for Appliance Communications in the Home			
PAP 16 - Wind Plant Communications			
PAP 17 - Facility Smart Grid Information Standard			
PAP 18 - Proposal for SEP 1.x to 2.0 Transition and Coexistence	TBD	TBD	TBD

=Complete/Closed =On Target =Late

=Tasking Complete =Caution

Source: SGIP March 2011 Activities - PMO Monthly Report

imagination at work

Collaboration is critical

Customers/ Vendors	Academic Institutions	Trade Associations	Technical Standards

imagination at work

Global Standards Collaboration

imagination at work

Smart Grid Recent Deployments and Lessons Learned

AEP Smart Grid Project

Summary

- American Electric Power is one of the largest electric utilities in the United States, delivering electricity to more than 5 million customers in 11 states
- 36,000 MW of generating capacity; 39K miles of transmission lines, 208K miles of distribution lines

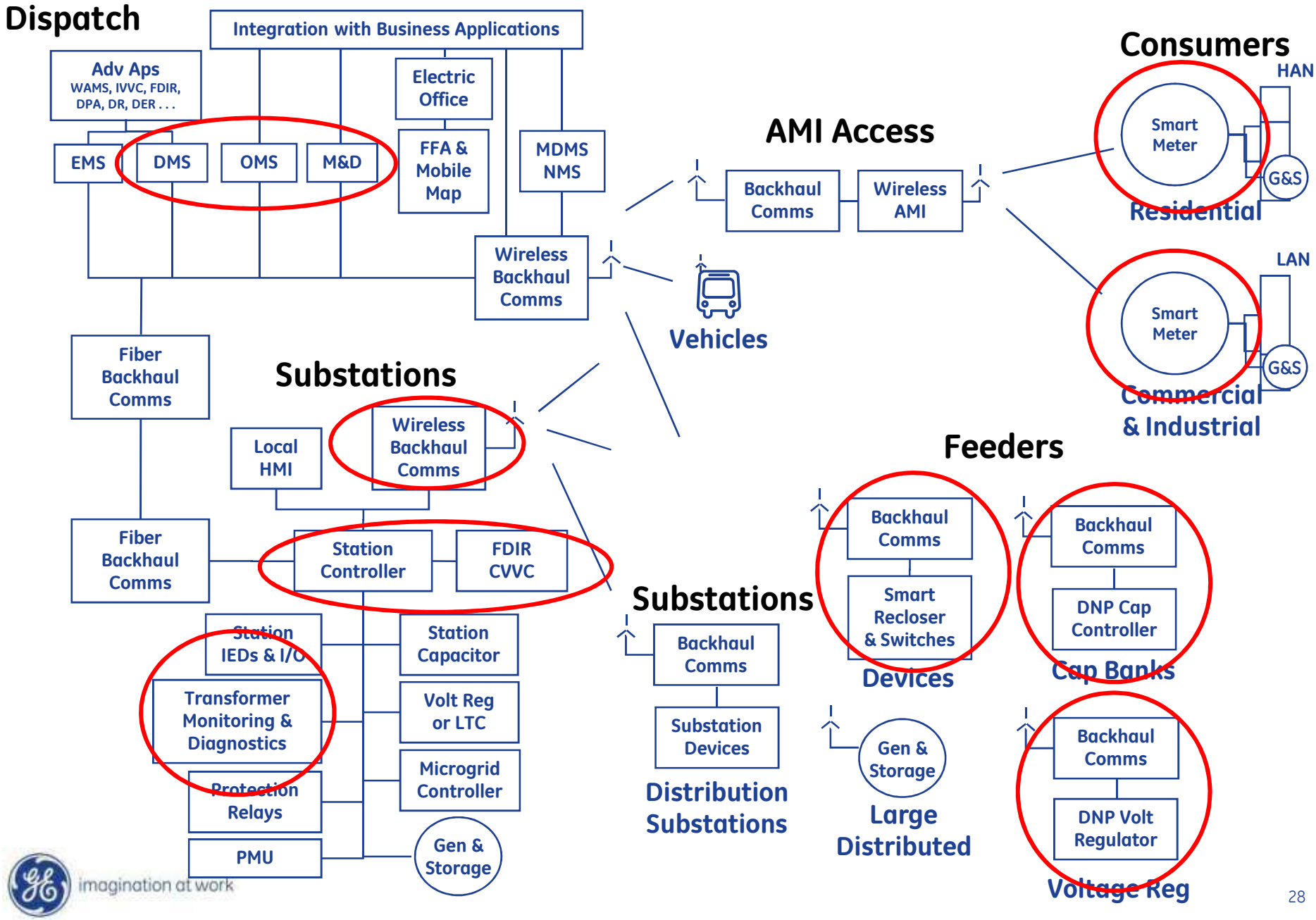
Drivers

- Enhanced Customer Experience (Customer control, tools to understand usage)
- Operational Efficiencies (Reduce operational costs of the network)
- Energy Efficiency
  - Utilize AMI infrastructure for Automation

Status

- Partnership developed to work together toward developing, demonstrating, & deploying Smart Grid solutions.
- Implement Smart Grid solutions to over 5MM customers by 2015
- First Smart Grid pilot complete in South Bend, IN. Next city-scale project in planning phase.
- GE and AEP working as partners to develop most effective Smart Grid

AEP Project – Integrated System View

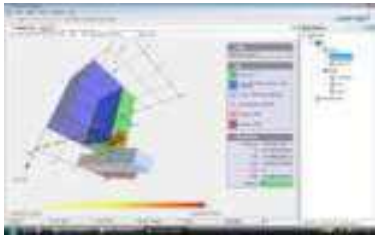


imagination at work

AEP Project – Solutions Delivered

Demand Optimization

- Smart meters with AMI
  - Time of use pricing
- Home Area Network
- Smart Appliances



Delivery Optimization

- Integrated Volt/Var Control
  - Analysis of theoretical and measured results
  - Analysis of financial benefits (MW, MWH, MVAR, and MVARH savings)
- Smart meters linked to Outage Management System (OMS)
- GENe DMS
- Poweron OMS
- Integration of DMS and OMS
- Leverage AMI for Distribution Automation

Asset Optimization

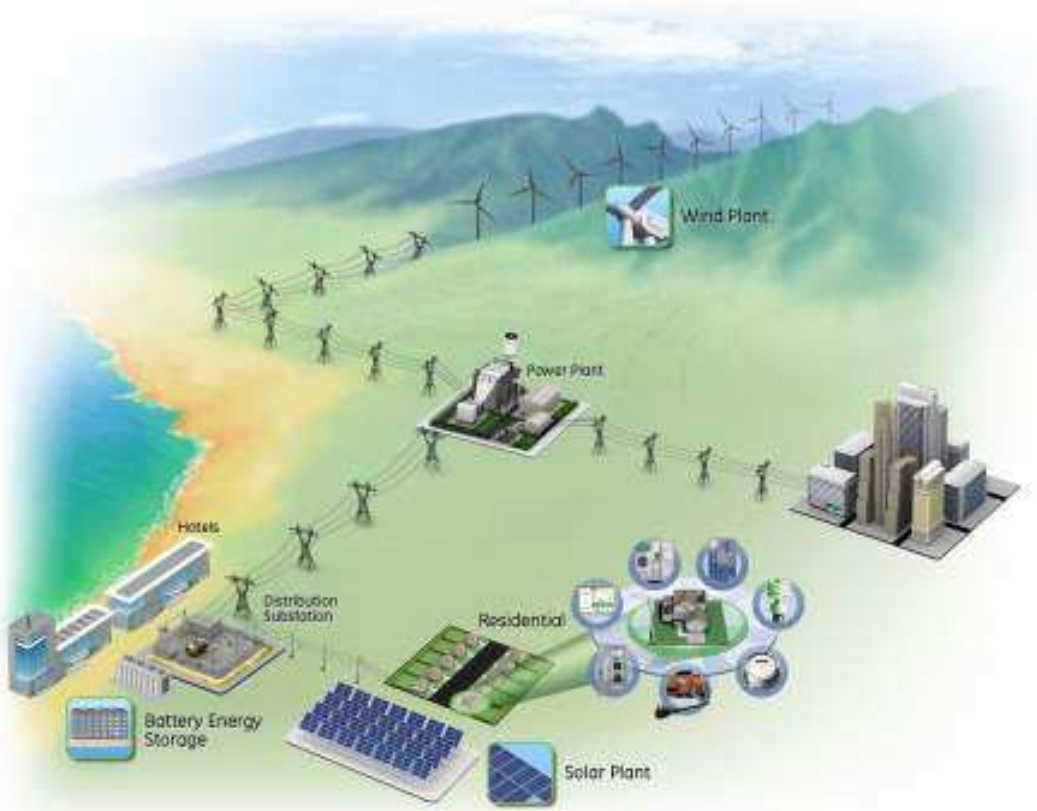
- Remote transformer monitoring of “at-risk” transformers.

imagination at work

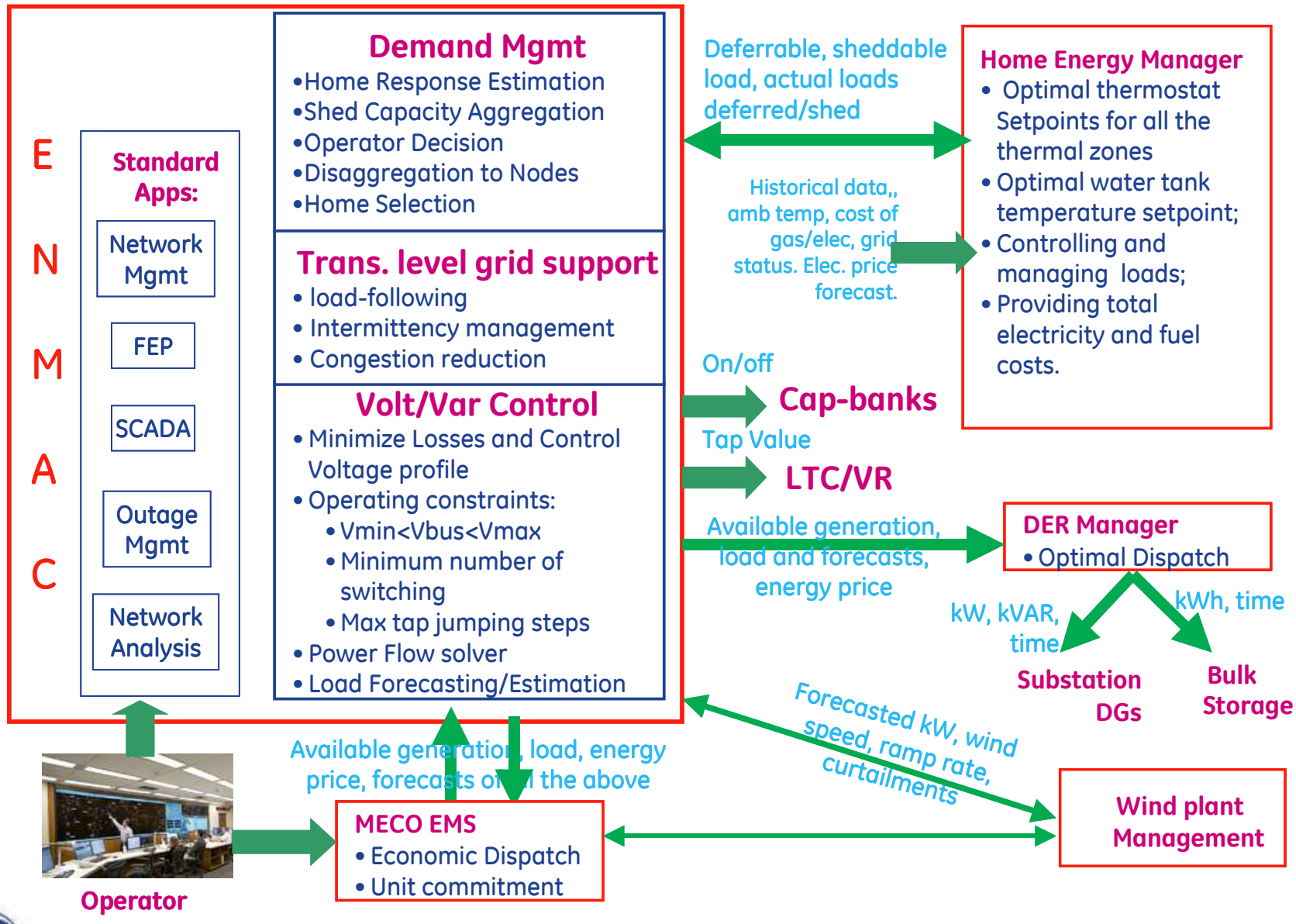
Maui Smart Grid Project

Develop a Smart Grid controls and communication architecture capable of *coordinating DG, energy storage and loads to*:

- Reduce peak load by 15% relative to loading on the distribution circuit.
- Mitigate the impacts of short-timescale wind and solar variability on the grid



Maui - Functional Description



imagination at work

Collaborations & alliances are critical

- $200M smart grid initiative
- ~800-1,000 “green collar” jobs
- Public/private alliance
  - ✓ GE
  - ✓ City of Miami
  - ✓ FPL
  - ✓ Cisco
  - ✓ Silver Spring Networks
- ~1MM customers involved
  - ✓ Smart Meters
  - ✓ Demand Management
  - ✓ Distribution Automation
  - ✓ Substation Intelligence
  - ✓ Distributed Generation
  - ✓ Enterprise Systems

ENERGY smart MIAMI

“It’s time for action. With projects like Energy Smart Miami, we can stimulate the economy today and build a brighter, cleaner tomorrow. It’s truly a win-win.”

Carol Browner

Assistant to the President for Energy and Climate Change

imagination at work

Energy smart cities

Miami proposes to lead the nation in energy efficiency with $200 million smart grid initiative

The Miami Herald

HOME | NEWS | SPORTS | ENTERTAINMENT | BUSINESS | LIVING | OPINION | JOBS

Editorials | Other Views | Letters | Columnists | Blogs | Cartoons

Posted on Sunday, 04.26.09

Recommend (0) share email print comment reprint

Miami: A 'green' leader

Regarding the April 21 story *Green push could help save power at home*: Congratulations to the city of Miami for being one of the first major U.S. cities to develop a smart grid to reduce energy consumption. Such innovation lays groundwork for a green U.S. economy.

Installing solar panels, building wind turbines, renovating buildings to make them more energy efficient, constructing the Smart Grid are all jobs that can't be outsourced. Moreover, Miami is rapidly becoming the "Greenway to the Americas" for energy- and water-saving products and services.

President Obama's economic-recovery package made a down payment on a clean-energy future, and Miami's Smart Grid is an important first step. Now Congress needs to follow with strong, comprehensive climate and energy legislation to kindle the green economy and put our country and Miami back on the path to prosperity.

Scope and revenue

- Average city scope ~200k endpoints
- Revenue pool ~$500/endpoint
- ~20 cities in wave 1 …. New York, Chicago, Detroit, San Francisco, London, Lyons
- Implementation over 2-3 yrs

Global growth + city scale expansion … $1B/yr opportunity

imagination at work

Smart Grid Lessons Learned

Technology:

- Challenge: “Hype” versus “Reality”
  - Utility expectations were that basic SG solutions were “shovel–ready”
  - Reality - Component technology was not as mature as advertised when combined to create a Smart Grid Solution
  - In many cases components were field re-engineered or upgraded to meet objectives and expectations
- Challenge: Integration / Interoperability
  - Integrating multiple supplier products to create a SG solution
  - Lesson Learned: adopt and insist on standards and open architecture methodology – drive for plug and play solutions
- Test, Test, Test
  - Lesson Learned: Extensive lab testing for “SG Solutions” is mandatory prior to implementation – understand the capabilities
  - Re-do’s are expensive and time consuming!

Smart Grid Lessons Learned

Implementation & Deployment:

- Challenge: Coordinating multiple suppliers
  - Managing equipment, shipments & delivery – pieces and parts along with assembly required for implementation (e.g., radio, controller, AMI network, substation equipment with software)
  - Coordinating software functionality with multi-supplier hardware and AMI
  - Lesson Learned: Minimize niche suppliers – prefer alliance suppliers with strong engineering and solution teams
- Challenge: Coordinating multiple internal departments
  - Managing Substation and Distribution Engineering, Protection and Control, Communications and Construction
  - Lesson Learned: Engage 1 Project Manager for each Smart Grid solution with multi-discipline authority
- Prefer packaged solutions from fewer suppliers – minimize the finger-pointing

Smart Grid Lessons Learned

Project Management:

- Establish Program Management Office
  - Multiple Project Managers reporting to the Program Manager
  - Adhere to PM guidelines such as Communication, Status Reporting, Risk Management, etc.
  - Build an "A" team with project and technical members – there will be challenges to collectively solve
- Establish Corporate Steering Committee
  - Key status meetings with Utility Executives and Alliance Suppliers
  - Escalation and Risk Mitigation in timely manner is critical
- Build Strategic Alliances with Key Suppliers
  - Define, Engineer and Build the Smart Grid solutions collectively
  - Alliance Supplier provides "On-site" management and technical support

Smart Grid Lessons Learned

Change Management:

- Smart Grid solutions involve multiple stakeholders (actors)
  - Residential / Commercial customers are now a “Major Stakeholder”
  - For example: PCT’s, In-home devices, utility incentivized customer programs, 2-way communication with the Utility
- Define and develop “Use-Cases” for each component of Smart Grid
  - Use-Cases provide – a scenario description, defines the benefits, actors, functional requirements, and business rules and assumptions
  - Lesson Learned: Use-cases form the basis for the benefits achieved, functional requirements, development, and training
  - Smart Grid actors require “Significant Training” on the operation and maintenance of the deployed system (i.e., Operations Center, Communications, Customer Call Center, Engineering, Field Crews, etc.)

Q&A